



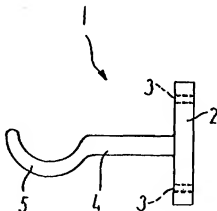
## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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(54) Title: A HANGER IN A COMBUSTION CHAMBER IN A COMBUSTION PLANT

## (57) Abstract

A hanger (1) in a combustion chamber in a combustion plant, such as a refuse incineration plant or a combustion plant in a power station has a surface which is exposed to corrosive influence from the combustion products. The surface material is a hot-corrosion-resistant nickel and chromium containing material made from a particulate starting material which by a HIP process has been unified to a coherent material substantially without melting the starting material. In terms of per cent by weight and apart from the common impurities and inevitable residual amounts of deoxidizing components the corrosion-resistant material comprises from 38 to 75 % Cr, at the most 0.15 %, at the most 1.5 % Si, at the most 1.0 % Mn, at the most 0.2 % B, at the most 5.0 % Fe, at the most 1.0 % Mg, at the most 2.5 % Al, at the most 2.0 % Ti, at the most 8.0 % Co, at the most 3.0 % Nb and a balance of Ni, the aggregate contents of Al and Ti amounting at the most to 4.0 %, and the aggregate contents of Fe and Co amounting at the most to 8.0 %, and the aggregate contents of Ni and Co amounting at the least to 25 %. The corrosion-resistant material has a hardness of less than 310 HV measured at approximately 20 °C after the material has been heated to a temperature within the range of 550-850 °C for more than 400 hours.



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A hanger in a combustion chamber in a combustion plant

The present invention relates to a hanger in a combustion chamber in a combustion plant, such as a refuse incineration plant or a combustion plant in a power station, in which at least the surface of the hanger, which is exposed to corrosive influence from the combustion products, is made of a hot-corrosion-resistant material containing nickel and chromium.

A hot-corrosion-resistant material in the present context means a material which is resistant to corrosion in the environment existing in the combustion chamber at an operating temperature ranging from 550°C to 1000°C.

Hot-corrosion-resistant alloys containing chromium and nickel normally age-harden at temperatures exceeding 550°C, viz., the alloy becomes harder and more brittle. In the case of cast members, to achieve excellent hot corrosion resistance, particularly in environments containing sulphur and vanadium from combustion products, it is known to use an alloy of the type 50% Cr and 50% Ni or an alloy of the type IN 657 consisting of 48-52% Cr, 1.4-1.7% Nb, at the most 0.1% C, at the most 0.16% Ti, at the most 0.2% C+N, at the most 0.5% Si, at the most 1.0% Fe, at the most 0.3% Mg and a balance of Ni. After casting, the alloy comprises a nickel-rich  $\gamma$ -phase and a chromium-rich  $\alpha$ -phase where both phases, depending on the accurate analysis of the alloy, may constitute the primary dendrite structure. It is known that these alloys age-harden at operating temperatures exceeding 600°C. This is because the alloy, when it cools off, does not solidify in its equilibrium state. When the alloy is subsequently at the operating temperature, precipitation of the under-represented phase proportion occurs by transformation of the over-repre-

sented phase proportion, which causes embrittlement characterized in a ductility of less than 4% at room temperature. Owing to these relatively poor strength properties, the alloys have been used exclusively for  
5 low-load cast members.

Hangers in combustion chambers are used for supporting pipes and other elements to be mounted in the chamber. The hanger is typically mounted on the wall or ceiling, and during normal operation of the plant, the  
10 hanger is continuously loaded by the gravitational influence of the element supported and by any dynamic loads produced by vibrations in the element. When the combustion in the chamber is stopped or initiated heat stresses further occur at the locations where the hanger  
15 changes geometry, for example at the transition between a body piece and a mounting flange.

It is technically feasible to manufacture the hanger from a material suitable for resisting the mechanical loads, such as steel, and provide the steel  
20 body with a facing of a hot-corrosion-resistant material, which can be applied as a coating by immersion of the steel body in melted material or by means of welding.

It is well-known that nickel and chromium contain-  
25 ing alloys with a high content of chromium may provide good resistance to hot corrosion, but also that these alloys become very hard and thus brittle at temperatures exceeding 550°C. A facing of such a material will often crack and thus expose the subjacent load-bearing  
30 material, which is then eroded away by the corrosive environment. Hangers with such a facing have to be inspected frequently and replaced when defects are ascertained.

The object of the present invention is to provide a hanger with an advantageously long life for the hot-corrosion-resistant material.

In view of this, the hanger according to the invention is characterized in that the corrosion-resistant material is made of particulate starting material, which by a HIP process has been unified to a coherent material substantially without melting of the starting material, that in terms of per cent by weight and apart from the common impurities and inevitable residual amounts of deoxidizing components the corrosion-resistant material comprises from 38 to 75% Cr and optionally from 0 to 0.15% C, from 0 to 1.5% Si, from 0 to 1.0% Mn, from 0 to 0.2% B, from 0 to 5.0% Fe, from 0 to 1.0% Mg, from 0 to 2.5% Al, from 0 to 2.0% Ti, from 0 to 8.0% Co, from 0 to 3.0% Nb as well as optional components of Ta, Zr, Hf, W and Mo, and a balance of Ni, the aggregate contents of Al and Ti amounting at the most to 4.0%, and the aggregate contents of Fe and Co amounting at the most to 8.0%, and the aggregate contents of Ni and Co amounting at the least to 25%, and that the corrosion-resistant material has a hardness of less than 310 HV measured at approximately 20°C after the material has been heated to a temperature within the range of 550-850°C for more than 400 hours.

Quite surprisingly it has proved that the material of this composition produced by the HIP process does not harden at the operating temperatures to which the hanger is exposed, and it is thus possible to maintain an advantageous low hardness of less than 310 HV20 and associated suitably high ductility of the hot-corrosion-resistant material. The low hardness limits or prevents crack formation in the material. The invention provides the further advantage that the material retains very fine mechanical properties even after a long-term heat

influence. Thus the material retains a high tensile strength combined with high ductility, which is quite unusual for nickel alloys with a high content of chromium. These properties also render it possible for  
5 the corrosion-resistant material to replace at least part of the usual load-bearing material of the hanger so that it can be formed with a lower weight than the hangers where the corrosion-resistant material is arranged as a facing on the outside of the material  
10 required for strength. In addition the effect is a saving in material. At the same time the material is extremely resistant to hot corrosion.

To avoid considerable hardening of the hot-corrosion-resistant material when the hanger is put to use,  
15 it is essential that the particulate starting material is neither melted nor exposed to considerable mechanical deformation at the manufacture of the hanger. The HIP process unifies the particulate starting material by, i.e., diffusion-based breakdown of the boundaries  
20 between the particles, which retains the very dense dendritic structure of the particles with closely adjacent dendrite branches. If the starting material were melted in connection with casting or welding, subsequent heating to temperatures exceeding 550°C would  
25 release the inherent tendency of these materials to age-harden or precipitation harden to a high hardness. So far, in metallurgical terms no satisfactory explanation can be given for the suppression of the hardening mechanism in the HIP-produced material in the hanger  
30 according to the invention, but it has surprisingly proved to be the case.

If the content of chromium of the material becomes less than 38%, the desired resistance to hot corrosion is not obtained. At the surface of the hanger, chromium  
35 reacts with oxygen to form a surface layer of  $\text{Cr}_2\text{O}_3$

protecting the subjacent material from the influences from the corrosive residual combustion products. The Cr content may advantageously be higher than 44.5%. If the content of chromium exceeds 75%, the nickel content of 5 the material becomes too low, and in addition at the high temperatures used for the HIP process undesired local transformations into pure  $\alpha$ -phase may occur, viz., a chromium-rich phase without dendritic structure. The  $\alpha$ -phase is brittle, and increasing proportions of this 10 phase in the structure negatively affect the ductility of the material. Preferably the Cr content of the material is higher than 49% in order thus to increase corrosion resistance.

The material has to have aggregate contents of 15 cobalt and nickel of at least 25% to have the desired ductility counteracting cracking. If the alloy does not contain Co, the Ni content thus has to be at least 25%. Apart from said lower limit for the chromium content, there is no structurally motivated upper limit to the 20 content of nickel.

If the C content exceeds 0.15%, undesired carbide boundary layers may precipitate on the particle surfaces, and precipitation of hardness-increasing carbides, such as NbC, WC or TiC, may also occur. Depending 25 on the amounts of the other components of the material, C may also form undesired chromium carbides. To achieve high safety against precipitation of carbide compounds the C content is preferably less than 0.02%, but since C is a common impurity in many metals it may be suitable 30 for economic reasons to limit the C content to 0.08% at the most.

A silicon content of up to 1.5% can contribute to improved corrosion resistance, Si forming silicon oxides at the surface of the material, which are very stable 35 in the environment existing in a combustion chamber. If

the Si content exceeds 1.5%, undesired amounts of hardness-increasing silicides may precipitate. Si may also have a solution-strengthening effect on the nickel-rich  $\gamma$ -phase in the basic structure of the material. For 5 this reason it may be desirable to limit the Si content of the material to 0.95% at the most.

Like Si, aluminium can improve corrosion resistance by forming aluminium oxide on the surface of the hanger. Furthermore, Al, Si and/or Mn may be added at the 10 manufacture of the particulate starting material, these three components having a deoxidizing effect. As Mn does not contribute to the desired material properties of the hanger, the residual amount of Mn in the material is desirably limited to 1.0% at the most.

15 Up to 0.5% Y and/or up to 4.0% Ta may be added to stabilize the oxide formations on the surface of the material in the same manner as at additions of Al and Si. Larger amounts of yttrium and tantalum do not provide any further improvement of the corrosion 20 resistance.

Al may form a hardness-increasing intermetallic compound with nickel ( $\gamma'$ ), and therefore the material may contain at the most 2.5% Al. If the alloy also contains Ti in larger amounts of at the most 2.0%, the 25 aggregate contents of Al and Ti of the material may not exceed 4.0%, as Ti may also form part of the undesired  $\gamma'$ -precipitations. To benefit from the corrosion-protective effect of aluminium and at the same time obtain a suitable safety against precipitation of  $\gamma'$ , 30 the material preferably contains less than 1.0% Al, the aggregate contents of Al and Ti at the same time amounting to 2.0% at the most. If the alloy contains Ti in an amount near the upper limit therefor, the Al content can advantageously be limited to 0.15% at the



most. To further suppress the formation of  $\gamma'$ , the Al content is preferably less than 0.4%.

Ti is a frequently occurring component of alloys containing chromium and nickel, and therefore it may be difficult to completely avoid a certain Ti content in the material. Preferably the Ti content is less than 0.6% to counteract precipitations of hardness-increasing titanium carbides and borides. The interaction between Al and Ti renders it desirable to limit the Ti content to less than 0.09% so that Al can be added in amounts that can improve the resistance of the material to hot corrosion.

The Fe content of the material is desirably limited to 5% at the most, the corrosion resistance decreasing with a higher Fe content. It is also possible to use a starting material containing cobalt, which does not have a negative influence proper on the corrosion resistance. Cobalt can partly replace nickel in the material if desirable for economic reasons. In amounts of up to 8.0% Co has no noticeable solution-strengthening effect on the  $\gamma$ -phase. Also in the cases when a nickel substitute is not desired, additions of cobalt in amounts of up to 8.0% may be desirable because Co can alter the relative amounts of  $\alpha$ -phases and  $\gamma$ -phases in a direction advantageous to the ductility of the material in that Co promotes formation of the  $\gamma$ -phase. This may be desirable in particular if the material contains much Cr, for example more than 60% Cr.

Boron can contribute to the particulate starting material of the mixed phase  $\alpha+\gamma$  having a very dense dendritic structure with a short distance between the dendrite branches. If the B content exceeds 0.2%, the amount of boron-containing eutectic and boride precipitations may assume an extent producing an undesired hardness-increasing effect. In amounts of up to 0.15%,

Zr may have the same favourable effect on the dendritic structure of the material as B and can therefore be used as an alternative or as a supplement to the addition of B. Preferably the B content is less than 0.09% to limit  
5 the amount of hardness-increasing precipitations.

The particulate starting material may contain residual amounts of magnesium, but this component apparently entails no advantages in the present use, and therefore the Mg content of the material is desirably  
10 limited to 1.0% at the most.

In a preferred embodiment the content in the material of the inevitable impurities N and O is limited to at the most 0.04% N and/or at the most 0.01% O. The content of O in the starting material may cause oxide  
15 coatings on the particles, and after the HIP process such coatings will be present as inclusions in the material, reducing its strength. The amount of N can advantageously be limited to said 0.04% to counteract the formation of hardness-increasing nitrides or  
20 carbonitrides.

Niobium can be added to the alloy used in the manufacture of the particulate starting material. For economic reasons the Nb content is preferably limited to 0.95% at the most, but if the alloy contains notice-  
25 able amounts of N and amounts of C near the upper limit of 0.15%, it may be desirable to add up to 2.0% Nb to neutralise the tendency of N and C to form undesired carbide and nitride boundary layers on the particle surfaces. In the corrosion-resistant material niobium  
30 in amounts of up to 3.0% has surprisingly proved to have a positive influence on the structural transformations occurring at long-term operation of the hanger in the relevant temperature range. Thus an Nb content of more than 0.1% and preferably from 0.9 to 1.95% contributes

to the material retaining a high ductility after long-term operation.

W and Mo are undesired components in the material, and if they occur, the material preferably contains less than 1.4% W and less than 0.9% Mo and the aggregate contents of W and Mo are less than 2%. This is due to the fact that both W and Mo have a solution-strengthening effect on the basic structure in the material, the  $\alpha$ - $\gamma$  phase, which increases the hardness. To avoid precipitation of intermetallic compounds based on W and Mo, the aggregate contents of W and Mo are preferably less than 1.0%.

Hf in amounts of 0.1-1.5% have a grain boundary modifying effect which has a positive effect on the ductility of the material at the operating temperature of the material in the range of 550-850°C.

It is well-known that a facing of pure chromium on the surface of an element provides an extremely good corrosion resistance, but also that such a facing is very brittle without noticeable ductility. With the present invention it is possible to mix particles of a chromium content of more than 75 per cent by weight, such as pure chromium particles, into the starting material. Thus the hanger can be provided with a surface layer having a further improved corrosion resistance. The consequent reduced ductility of the surface layer may lead to cracking in it. The cracks will expose the subjacent material which, as described above, has a high ductility, which prevents the cracks from developing in to deeper cracks, and is hot corrosion resistant, limiting the corrosive erosion. The addition of the high-chromium-content particles thus enables the provision of a hanger having an optimum combination of corrosion resistance and ductility.

During the life of the hanger, the chromium content in the crystal grains near the surface will be reduced in step with the burning off of the chromium oxides at the surface of the element. The addition of the high-chromium-content particles counteracts this tendency as the high temperature level at the surface makes chromium from the high-chromium-content particles diffuse into the adjacent crystal grains of the composition indicated in claim 1. Thus a varied composition may be imparted to the particulate starting material with a falling content of high-chromium-content particles at an increasing distance from the surface of the hanger.

With a view to obtaining high ductility, the corrosion-resistant material preferably has a hardness of less than 300 HV after heating to the temperature mentioned in claim 1 for said time, and even more advantageously the hardness is less than 285 HV, measured at approximately 20°C.

In a preferred embodiment the corrosion-resistant material extends through the thickness of the entire hanger, viz., the hanger as an entirety or, if the hanger comprises several components, the components of the hanger as an entirety is/are made from the corrosion-resistant material. This does entail a higher consumption of the relatively costly starting material, but at the same time it obviates any problem of erosion of a corrosion-protective facing on a stronger base material. Whether it is most advantageous to manufacture the whole hanger from the corrosion-resistant material or to provide a basic body with a corrosion-protective facing depends, i.e., on the dimensions and geometry of the hanger. If the hanger has a section with a very large thickness, it is also possible to insert a core piece of a cheaper material or to use cheaper particulate material at the middle of the hanger to

achieve a saving in the consumption of the particulate starting material.

As a consequence of the fact that the corrosion-protective material is applied in a HIP process, the thickness of material can be chosen according to need by merely using the particulate starting material in an amount adapted to the desired thickness. This is a pronounced advantage compared with, for example, welding on of a facing where the welding procedure has to be repeated many times if larger layer thicknesses are desired.

Examples of the invention will now be explained in further detail below with reference to the very schematic drawing showing a side view of an example of a hanger according to the invention.

A hanger 1 comprises a flange piece 2 which may be mounted on the inner surface of the wall of a combustion chamber of a furnace, a refuse incineration plant or a combustion plant of a power station, for example, by means of bolts, pins or screws, not shown, inserted through holes 3 in the flange piece. It is also possible to insert the flange piece in suitable holding recesses in the wall, and in this case the holes 3 can be omitted.

A body section 4 projects from the flange piece and has a length adapted to the distance of the supported element to the wall in the combustion chamber. The body section 4 passes over into a supporting section 5 which may be curved, as shown, when the hanger is to support a pipe. Other designs are also possible. The hanger may, for example, comprise several components clamped together at the mounting of the supported element.

As mentioned above, the hanger is made fully or partially by means of a HIP process. The HIP process is well-known (HIP is an abbreviation of Hot Isostatic

Pressure). This process uses particulate starting material which may, for example, be manufactured by atomization of a liquid jet of a melted nickel and chromium containing alloy into a chamber with an inactive atmosphere, whereby the drop-shaped material is quenched and solidifies as particles with the very dense dendritic structure  $\alpha+\gamma$ . The particulate material may also be called a powder.

The particulate starting material is placed in a mould in an amount optionally adjusted to the desired thickness of the corrosion-resistant material. As mentioned, at the same time high-chromium-content particles may be admixed. Then the mould is closed and a vacuum is applied to extract undesired gases. Then the HIP process is started in which the particulate material is heated to a temperature ranging from 950 to 1200°C, and a high pressure of, for example, 900 to 1200 bar is applied. At these conditions the starting powder becomes plastic and is unified to a coherent, dense material substantially without melting. Then the hanger is removed and, if necessary, machined to the desired dimensions.

Examples will now be given below to illustrate the mechanical properties of the hot-corrosion-resistant material.

#### Example 1

Based on particulate starting material analyzed at 46% Cr, 0.4% Ti, 0.05% C and a balance of Ni, a rod-shaped body with a diameter of 30 mm and a length of approximately 1000 mm was manufactured by means of the HIP process. After placing in the mould, the starting material was heated to a temperature of 1150°C and pressurized to approximately 1000 bar, and after a dwell time of approximately 2.5 hours at these conditions the

body was returned to room temperature and normal pressure. From the rod-shaped body, sample discs approximately 8 mm thick were cut. The average hardness of the discs was measured at 269 HV20 at room temperature. The discs were then heat treated at a temperature of 700°C for 672 hours. After the heat treatment the average hardness of the discs at room temperature was measured at 285 HV20. It could thus be ascertained that the heat treatment only gave rise to a very limited increase in hardness.

#### Example 2

Based on particulate starting material analyzed at 49.14% Cr, 1.25% Nb, 0.005% C and a balance of Ni a rod-shaped body was manufactured in the same manner as in Example 1, and sample discs were cut, the average hardness of which was measured at 292 HV20. The discs were then heat treated at a temperature of 700°C for 672 hours, whereupon their average hardness was measured at 260 HV20. It could thus be ascertained that the heat treatment gave rise to a reduction in hardness.

#### Example 3

In the same manner as in Example 1, three rod-shaped bodies were then manufactured, the first one of which was analyzed at 46% Cr, 0.4% Ti, 0.05% C and a balance of Ni, the second one of which was analyzed at 49.14% Cr, 1.25% Nb, 0.005% C and a balance of Ni, and the third one of which was analyzed at 54.78% Cr, 1.26% Nb, 0.005% C, 0.1% Fe and a balance of Ni. From each of the three bodies, pieces 120 mm long were cut and machined in the usual manner into tensile test pieces. The test diameter of the test pieces with 46% Cr was 3 mm, while the test diameter of the test pieces of the two other alloys was 5 mm. The average hardness of the test pieces

was measured, whereupon a batch of test pieces was heat treated for 48 hours at 700°C, a second batch of test pieces was heat treated for 336 hours at 700°C, and a third batch of test pieces was heat treated for 672 hours at 700°C. Out of the two last-mentioned alloys a fourth batch of test pieces was furthermore manufactured with a test diameter of 6 mm. The fourth batch of test pieces was heat treated for 4392 hours at 700°C. After the heat treatments the average hardness at room temperature of the test pieces was measured, and tensile tests and impact tests were carried out at room temperature to test the mechanical properties of the materials. The hardness measurement was carried out according to the Vickers method (HV20), and the impact strength was measured according to Charpy's U-notch test in which the minimum load-bearing area of the test pieces was fixed at 0.5 cm<sup>2</sup>. The test results are reproduced in the below Tables 1 and 2. It should be noted that the measuring results marked by an asterisk indicate test pieces which fractured prematurely owing to a machining error.

The test results show that the HIP-manufactured hot-corrosion-resistant material does not have its ductility reduced by a long-term heat load at a temperature level representative of operating temperatures for a hanger of the present type.

It also appears that the other mechanical properties of the material are excellent. The tensile strength of the material before heat treatment is substantially higher than is usual for nickel alloys with a high content of chromium. The heat treatment is seen to give a limited drop in tensile strength down to a level which is still advantageously high. The heat-treated test pieces generally exhibit an elongation at rupture of more than 20%. At the heat treatment, also an increase in elongation at rupture and in area



reduction is seen, which means that the material gets a higher ductility. It also appears that the niobium containing materials heat treated for just below 4400 hours achieve an elongation at rupture of approximately 5 30%, the area reduction being at approximately 50% after long-term heat influence. At the heat treatment from 672 to 4392 hours, the elongation at rupture is seen to have increased by up to 50%. These results show that the corrosion-resistant materials according to the invention 10 are valid construction materials with extremely fine strength properties, also after a long-term heat influence.

The materials also appear to have an extremely high impact strength. Compared to the impact strength of the 15 HIP-manufactured material, the impact strength is increased considerably by the heat treatment which imitates the operating conditions of the materials. Thus, apart from immaterial reductions of yield stresses and tensile stresses, the corrosion-resistant materials 20 achieve better strength properties in operation at temperatures ranging between 550°C and 850°C.

The extremely fine mechanical properties of the material render it suitable as a construction material proper, which at the same time has the excellent corrosion-resistant properties known *per se*. 25

As further examples of corrosion-resistant materials according to the invention may be mentioned the material with the following composition: 60% Cr, at the most 0.02% C, at the most 0.2% Si, at the most 0.5% 30 Mn, at the most 0.5% Mo, at the most 0.2% Cu, at the most 0.005% B, at the most 0.002% Al, at the most 0.02% Ti, at the most 0.02% Zr, 1.25% Nb, at the most 0.5% Co, at the most 0.5% Fe, at the most 0.05% N, at the most 0.02% O, and a balance of Ni, and the material with the 35 following composition: 45% Cr, at the most 0.02% C, 1.5%

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Si, at the most 0.5% Mn, at the most 0.5% Mo, at the most 0.2% Cu, at the most 0.005% B, at the most 0.002% Al, at the most 0.02% Ti, at the most 0.02% Zr, 1.25% Nb, at the most 0.5% Co, at the most 0.5% Fe, at the  
5 most 0.05% N, at the most 0.02% O and a balance of Ni.

In the above description, all percentages of alloy components are expressed in terms of per cent by weight.

TABLE 1:

Heat Treatment Temperature/Time	Tensile strength $R_m$ N/mm <sup>2</sup>	0.2 Proof Stress $R_p$ N/mm <sup>2</sup>	Elong- ation $A_{tot}$ %	Reduction of Area Z %	Vickers hardness HV20 kp/mm <sup>2</sup>	U-notch Impact Strength J/cm <sup>2</sup>
<u>5 48% Cr, 0.4% Ti, 0.05% C and a balance of Ni</u>						
20°C	988	692	17.8	32.1	272	34
700°C/48 hours	944	597	25	43.4	270	38
700°C/336 hours	978	664	18	40.8	280	34
do.	976	646	18	46.2	do.	
10 700°C/672 hours	959	644	17	43.3	280	
do.	961	635	15	42.4	do.	
<u>49.14% Cr, 1.25% Nb, 0.005% C and a balance of Ni</u>						
20°C	1015	636	21	42.2	294	42
do.	1027	642	22	39.2	do.	
15 700°C/48 hours	916	605	23	50.0	268	50
do.	923	612	22	51.0	do.	
700°C/336 hours	904	598	22	52.8	270	60
do.	898	586	22	55.5	do.	
700°C/672 hours	910	573	22	52.8	264	
do.	848*	586	13*	44.1*	do.	
20 do.	879	611	30	48.6	263	58
700°C/4392 hours	883	565	31.7	46.2	do.	50
do.	883	569	26.7	51	do.	50
do.	891	565	31.7	51	do.	50

TABLE 2:

Heat Treatment Temperature/Time	Tensile Strength $R_m$ N/mm <sup>2</sup>	0.2 Proof Stress $R_p$ N/mm <sup>2</sup>	Elong- ation $A_{tot}$ %	Reduction Of Area $Z$ %	Vickers hardness HV20 kp/mm <sup>2</sup>	U-notch Impact Strength $J/cm^2$
5 54.78t Cr, 1.26t Ni, 0.005t C, 0.1t Fe and a balance of Ni						
20°C	113	740	13	15.4	331	18
do.	1100	734	11	11.6	do.	
700°C/48 hours	954	652	23	34.7	276	46
do.	960	667	22	44.1	do.	
10 700°C/336 hours	910	617	22	44.1	271	36
do.	910	611	21	44.1	do.	
700°C/672 hours	923	605	18	44.1	276	
do.	929	605	20	45.6	do.	
700°C/4392 hours	>777*	560	*	*	265	30
do.	879	556	30	41.2	do.	24
15 do.	883	556	28.3	43.7	do.	24
do.	874	560	28.3	48.6	do.	30

## P A T E N T C L A I M S

1. A hanger (1) in a combustion chamber in a combustion plant such as a refuse incineration plant or a combustion plant in a power station, in which at least the surface of the hanger, which is exposed to corrosive influence from the combustion products, is made of a hot-corrosion-resistant material containing nickel and chromium, characterized in that the corrosion-resistant material is made of particulate starting material, which by a HIP process has been unified to a coherent material substantially without melting of the starting material, that in terms of percent by weight and apart from the common impurities and inevitable residual amounts of deoxidizing components the corrosion-resistant material comprises from 38 to 75% Cr and optionally from 0 to 0.15% C, from 0 to 1.5% Si, from 0 to 1.0% Mn, from 0 to 0.2% B, from 0 to 5.0% Fe, from 0 to 1.0% Mg, from 0 to 2.5% Al, from 0 to 2.0% Ti, from 0 to 8.0% Co, from 0 to 3.0% Nb as well as 20 optional components of Ta, Zr, Hf, W and Mo, and a balance of Ni, the aggregate contents of Al and Ti amounting at the most to 4.0%, and the aggregate contents of Fe and Co amounting at the most to 8.0%, and the aggregate contents of Ni and Co amounting at the most to 25%, and that the corrosion-resistant material has a hardness of less than 310 HV measured at approximately 20°C after the material has been heated to a temperature within the range of 550-850°C for more than 400 hours.
2. A hanger according to claim 1, characterized in that the content of C of the material is less than 0.08%, preferably less than 0.02%.
3. A hanger according to claim 1 or 2, characterized in that the content of Al of the material is less than 1.0% and at the same time the

aggregate contents of Al and Ti amount at the most to 2.0%, and that suitably the content of Al is less than 0.4%, preferably less than 0.15%, and at the same time the content of Ti is less than 0.6%, preferably less than 0.09%.

4. A hanger according to any one of claims 1-3, ch a r a c t e r i z e d in that the content of Cr of the material is higher than 44.5%, preferably higher than 49%.

5. A hanger according to any one of claims 1-4, ch a r a c t e r i z e d in that the content of N of the material is at the most 0.04%, and suitably the content of O is at the most 0.01%.

6. A hanger according to any one of the claims 1-5, ch a r a c t e r i z e d in that the material further contains up to 0.5% Y and/or up to 4.0% Ta.

7. A hanger according to any one of claims 1-6, ch a r a c t e r i z e d in that the content of Nb of the material is at the most 2% and preferably in the interval from 0.1% to 1.95%, suitably at least 0.9%.

8. A hanger according to any one of claims 1-7, ch a r a c t e r i z e d in that the material further contains up to 0.15% Zr, and that the content of B of the material is suitably less than 0.09%.

9. A hanger according to any one of claims 1-8, ch a r a c t e r i z e d in that the material further contains from 0.1 to 1.5% Hf.

10. A hanger according to any one of claims 1-9, ch a r a c t e r i z e d in that the material further contains less than 1.4% W and less than 0.9% Mo, and that the aggregate contents of W and Mo are less than 2%, preferably less than 1.0%.

11. A hanger according to any one of claims 1-10, ch a r a c t e r i z e d in that particles with a chromium content of more than 75% by weight are mixed

into the starting material at least at the surface facing the combustion chamber.

12. A hanger according to any one of claims 1-11, characterized in that after heating to said temperature for said time the corrosion-resistant material has a hardness of less than 300 HV, preferably less than 285 HV measured at approximately 20°C.

13. A hanger according to any one of claims 1-12, characterized in that the corrosion-resistant material extends over the thickness of the entire hanger.

## AMENDED CLAIMS

[received by the International Bureau on 13 October 1997 (13.10.97);  
original claims 1-13 replaced by new claims 1-14 (3 pages)]

1. A hot-corrosion-resistant material containing nickel and chromium, the corrosion-resistant material being made of particulate starting material, which by  
5 a HIP process has been unified to a coherent material substantially without melting of the starting material, c h a r a c t e r i z e d in that in terms of per cent by weight and apart from the common impurities and inevitable residual amounts of deoxidizing components  
10 the corrosion-resistant material comprises from 38 to 75% Cr and optionally from 0 to 0.15% C, from 0 to 1.5% Si, from 0 to 1.0% Mn, from 0 to 0.2% B, from 0 to 5.0% Fe, from 0 to 1.0% Mg, from 0 to 2.5% Al, from 0 to 2.0% Ti, from 0 to 8.0% Co, from 0 to 3.0% Nb as well as  
15 optional components of Ta, Zr, Hf, W and Mo, and a balance of Ni, the aggregate contents of Al and Ti amounting at the most to 4.0%, and the aggregate contents of Fe and Co amounting at the most to 8.0%, and the aggregate contents of Ni and Co amounting at the  
20 least to 25%, and that the corrosion-resistant material has a hardness of less than 310 HV measured at approximately 20°C after the material has been heated to a temperature within the range of 550-850°C for more than 400 hours.

25 2. A hot-corrosion-resistant material according to claim 1, c h a r a c t e r i z e d in that the content of C of the material is less than 0.08%, preferably less than 0.02%.

3. A hot-corrosion-resistant material according to  
30 claim 1 or 2, c h a r a c t e r i z e d in that the content of Al of the material is less than 1.0% and at the same time the aggregate contents of Al and Ti amount at the most to 2.0%, and that suitably the content of Al is less than 0.4%, preferably less than 0.15%, and



at the same time the content of Ti is less than 0.6%, preferably less than 0.09%.

4. A hot-corrosion-resistant material according to any one of claims 1-3, characterized in 5 that the content of Cr of the material is higher than 44.5%, preferably higher than 49%.

5. A hot-corrosion-resistant material according to any one of claims 1-4, characterized in that the content of N of the material is at the most 10 0.04%, and suitably the content of O is at the most 0.01%.

6. A hot-corrosion-resistant material according to any one of the claims 1-5, characterized in that the material further contains up to 0.5% Y 15 and/or up to 4.0% Ta.

7. A hot-corrosion-resistant material according to any one of claims 1-6, characterized in that the content of Nb of the material is at the most 2% and preferably in the interval from 0.1% to 1.95%, 20 suitably at least 0.9%.

8. A hot-corrosion-resistant material according to any one of claims 1-7, characterized in that the material further contains up to 0.15% Zr, and that the content of B of the material is suitably less 25 than 0.09%.

9. A hot-corrosion-resistant material according to any one of claims 1-8, characterized in that the material further contains from 0.1 to 1.5% Hf.

10. A hot-corrosion-resistant material according 30 to any one of claims 1-9, characterized in that the material further contains less than 1.4% W and less than 0.9% Mo, and that the aggregate contents of W and Mo are less than 2%, preferably less than 1.0%.

11. A hot-corrosion-resistant material according 35 to any one of claims 1-10, characterized

in that after heating to said temperature for said time the corrosion-resistant material has a hardness of less than 300 HV, preferably less than 285 HV measured at approximately 20°C.

5        12. A hanger (1) in a combustion chamber in a combustion plant such as a refuse incineration plant or a combustion plant in a power station, in which at least the surface of the hanger, which is exposed to corrosive influence from the combustion products, is made of a  
10 hot-corrosion-resistant material containing nickel and chromium, c h a r a c t e r i z e d in that said material is a hot-corrosion-resistant material according to any one of claims 1-11.

13. A hanger according to claim 12, c h a r a c -  
15 t e r i z e d in that particles with a chromium content of more than 75% by weight are mixed into the starting material at least at the surface facing the combustion chamber.

14. A hanger according to claim 12 or 13,  
20 c h a r a c t e r i z e d in that the corrosion-resistant material extends over the thickness of the entire hanger.

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/DK 97/00220

## A. CLASSIFICATION OF SUBJECT MATTER

IPC6: C22C 19/05, C22C 27/06, F23M 13/00

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: C22C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

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A	EP 0529208 A1 (FUKUDA METAL FOIL & POWDER CO., LTD.), 3 March 1993 (03.03.93), page 1, line 1 - page 6, line 45 ---	1-13
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A	DE 1558719 A1 (HENRY WIGGIN & CO. LTD.), 23 April 1970 (23.04.70) ---	1-13

☒ Further documents are listed in the continuation of Box C.
 ☒ See patent family annex.

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"A" document member of the same patent family

Date of the actual completion of the international search

Date of mailing of the international search report

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## INTERNATIONAL SEARCH REPORT

International application No.

PCT/DK 97/00220

## C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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A	Patent Abstracts of Japan, Vol 14, No 417, C-756, abstract of JP, A, 2-159342 (TOSOH CORP), 19 June 1990 (19.06.90) ---	1-13
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06/08/97

International application No.

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